Analysis of Vehicle Crash Box for Improved Passengers Safety with Shape Optimization

Devendra Kantilal Chaudhari[1] P.N.Borse[2]
[1]PG Student (Mechanical-General) [2]Assistant Professor
[1,2]Department of Mechanical Engineering
[1,2]SGDCOE, Jalgaon, Maharashtra, India

Abstract— With the development in features of automobiles, safety is an important concern. Research is continuously made to improve the safety and to develop a device for the same. The crash box is one of the safety device attached to the vehicle body generally at front side which tends to deform during the frontal collision of vehicle and safeguards the passenger and vehicle component. In order to improve the safety of passengers and vehicle the author proposed a work on analysis and development of vehicle crash box of three different shape namely square, rectangular and circular and analysis is made using ANSYS in to study the energy absorption during collision and deforming behavior of crash box under the same impact loading condition. The crash box with minimum deformation and maximum energy absorption is then selected as an optimum design of crash box.

Keywords: Vehicle Crash Box, Passengers Safety

I. INTRODUCTION

The vehicle crash box is the safety device provided at the front of vehicle in order to improve the safety factor during the frontal collision to avoid damage to the vehicle and its components and passenger. The crash box performs this function during collision by deforming itself and absorbing energy of collision. It is observed that the deformation capacity and energy absorption can be varied by changing shape, size and material of the crash box. But in many cases the length of crash box is kept same as there is limitation to the overall size of vehicle hence these properties only depends on the shape and material. Therefore considering the problem of improved safety the author proposed a work on analysis if vehicle crash box for improved passenger safety with shape optimization. The author made three different shape of crash box mainly square, trapezoidal and circular by keeping length same in Catia-v5 and then analysis is performed using ANSYS for minimum deformation and maximum strain energy and the optimum shape of crash box is proposed.

II. DESIGN OF DIFFERENT SHAPE CRASH BOX

In order to study the behavior of crash box with different shape the author first made the different shape crash box using Catia-v5. Attention is given while designing that the slots are to be made at equal interval only as the deformation starts from there only. Figure 1, Figure 2 and Figure 3 shows the crash box with Square, Trapezoidal and Circular shape respectively and the table 1 represents the parameters of each crash box.

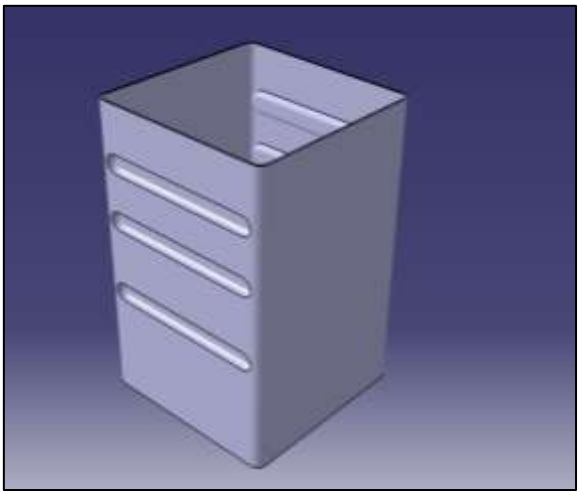

Fig. 1: Square Shape Crash Box

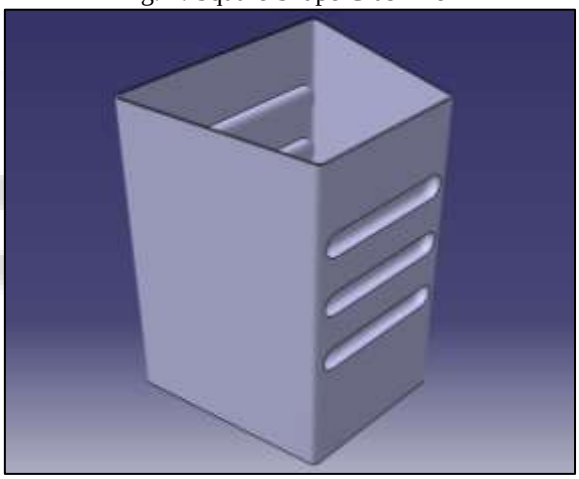

Fig. 2: Trapezoidal Shape Crash Box

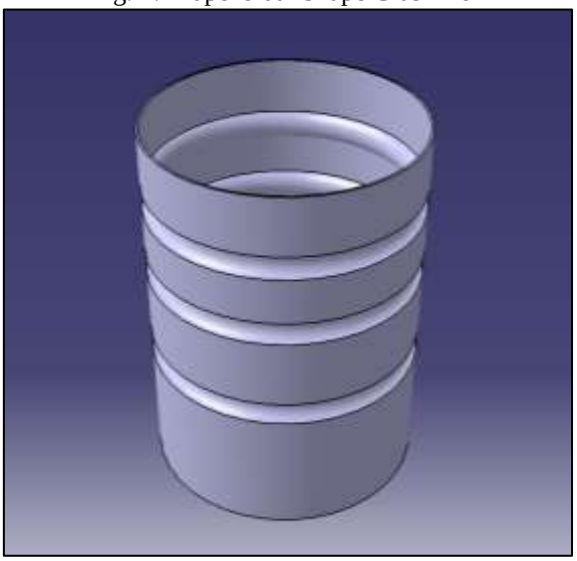

Fig. 3: Circular Shape Crash Box

Crash Box Shape	Length	Side A(mm)	Side B (mm)	Diameter (mm)
Square	160	100	100	__
Trapezoidal	160	120	80	__
Circular	160	___	__	57.5

Table 1: Geometrical Parameters of Crash Box

III. ANALYSIS OF DIFFERENT SHAPE CRASH BOX

A. Square Shape Crash Box

The different shape of crash box are made using CAD package and then imported to ANSYS for further analysis. The figure 4 shows the total deformation and figure 5 shows the strain energy of square shape crash box and the corresponding values are entered in table 2.

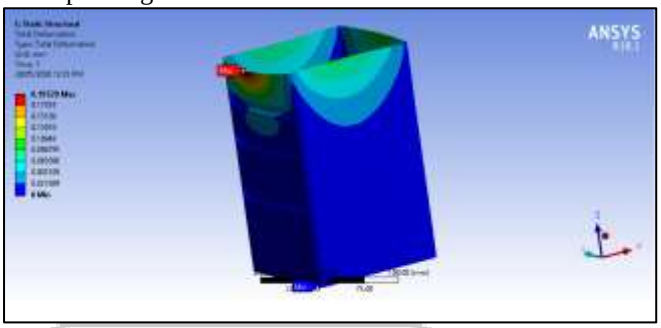

Fig. 4: Total Deformation of Square Shape Crash Box

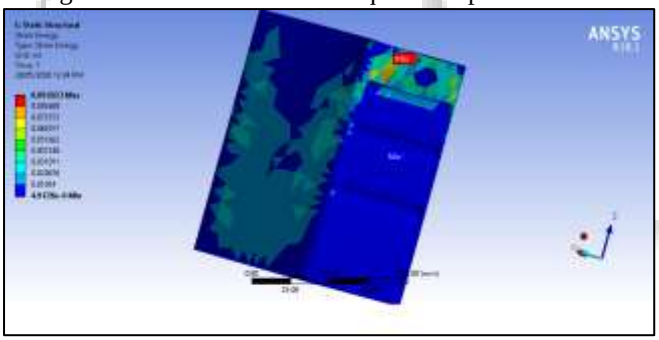

Fig. 5: Strain Energy of Square Shape Crash Box

Shape of Crash Box	Total Deformation (mm)	Strain Energy (mJ)
Square	0.19529	0.093023

Table 2: Total Deformation and Strain Energy of Square Shape Crash Box

B. Trapezoidal Shape Crash Box

The figure 6 shows the total deformation and figure 7 shows the strain energy of square shape crash box and the corresponding values are entered in table 3.

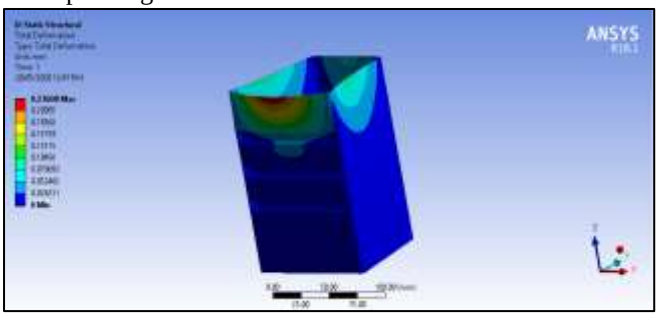

Fig. 6: Total Deformation of Trapezoidal Shape Crash Box

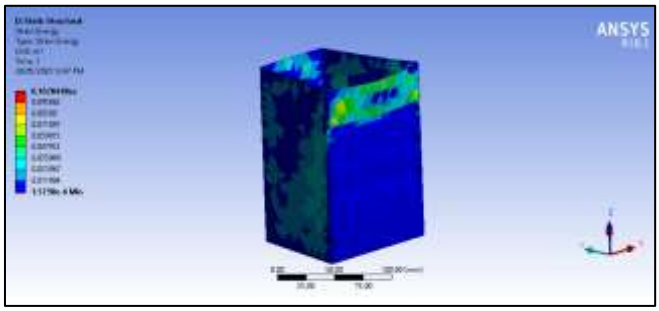

Fig.7 Strain Energy of Trapezoidal Shape Crash Box

Shape of Crash Box	Total Deformation (mm)	Strain Energy (mJ)
Trapezoidal	0.23608	0.10784

Table 3: Total Deformation and Strain Energy of Square Shape Crash Box

C. Circular Shape Crash Box

The figure 8 shows the total deformation and figure 9 shows the strain energy of square shape crash box and the corresponding values are entered in table 4.

Fig. 8: Total Deformation of Circular Shape Crash Box

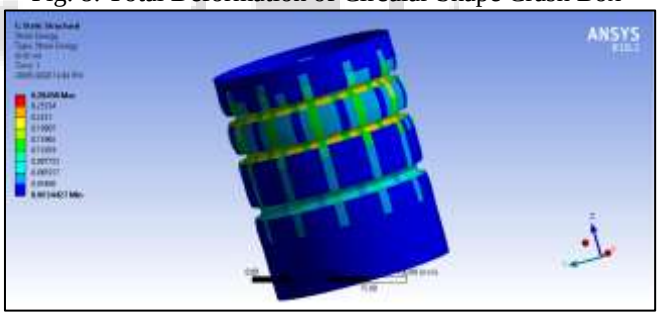

Fig. 9: Strain Energy of Circular Shape Crash Box

Shape of Crash Box	Total Deformation (mm)	Strain Energy (mJ)
Circular	0.056614	0.28458

Table 4: Total Deformation and Strain Energy of Circular Shape Crash Box

IV. RESULT & DISCUSSION

The table 5 shows the total deformation and strain energy of all shape crash box.

Shape of Crash Box	Total Deformation (mm)	Strain Energy (mJ)
Square	0.19529	0.093023
Trapezoidal	0.23608	0.10784
Circular	0.056614	0.28458

Table 5: Total Deformation and Strain Energy of All Shape Crash Box

From the table 5 it is cleared that the values of total deformation and strain energy for the same impact loading condition is optimum for circular shape crash box. That means the circular shaped crash box absorbs maximum energy during collision with minimum deformation to safeguard the vehicle component and passengers. Therefore the circular shape crash box is the optimum shape which improves passenger's safety during the frontal collision of vehicle.

ACKNOWLEDGEMENT

I am thankful to all of those with whom I have worked for successful completing of the work. I am very thankful to Prof. P.N.Borse for his kind support and sharing his valuable time. Each of the members of my work committee has provided me extensive personal and professional guidance.

REFERENCES

[1] Ince F., Turkmen H.S., Orene H. "experimental and numerical study on impact behavior of box structure" Elsevier Science Direct 2011.
[2] Ma Q.H., Zhang C.Y., Han S.Y. & Qin Z.T. "Research on the crash safety of car bumper based on different standard" 2013.
[3] Chaudhari C.D., Joshi A.P., Waghmare S.A. "Crash test for 40% offset frontal bumper car analysis using CAE"2013.
[4] Valayil T.P., Dr.Issac J.C. "crash simulation in ANSYS LS-DYNA to explore the crash performance of composite and metallic materials" international journal of science and research, volume 4,8august2013.
[5] Kim H.C., Kilshin D., Lee J.J. "crashworthiness of aluminum/CFRP square hollow section beam under axial impact loading for crash box application" Elsevier Science Direct www.elsevier.com ,5 february 2014.
[6] Boria S., J.Obrsdovic, G.Beligardi "Experimental and numerical investigation on impact behavior of composite frontal crash structure" received 27 may 2014: received in revised form 6 march 2015: accepted 11 April 2015

